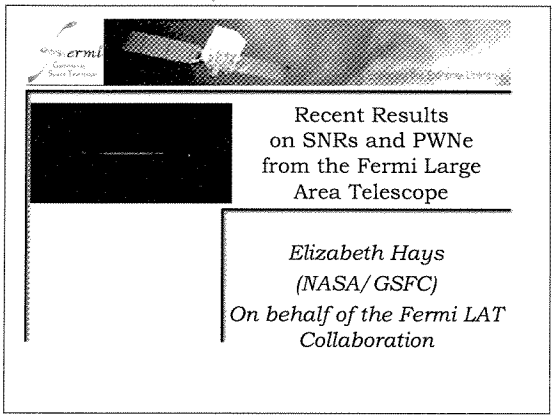


Recent Results on SNRs and PWNe from the Fermi Large Area Telescope

Elizabeth Hays
(NASA/GSFC)
On behalf of the Fermi LAT Collaboration

Fermi LAT Collaboration

- France
  - IN2P3, CEA/Saclay
- Italy
  - INFN, ASI, INAF
- Japan
  - Hiroshima University
  - ISAS/JAXA
  - RIKEN
  - Tokyo Institute of Technology
- Sweden
  - Royal Institute of Technology (KTH)
  - Stockholm University
- United States
  - Stanford University (SLAC and HEPL/Physics)
  - University of California at Santa Cruz - Santa Cruz Institute for Particle Physics
  - Goddard Space Flight Center
  - Naval Research Laboratory
  - Sonoma State University
  - Ohio State University
  - University of Washington

Principal Investigator:
Peter Michelson (Stanford University)

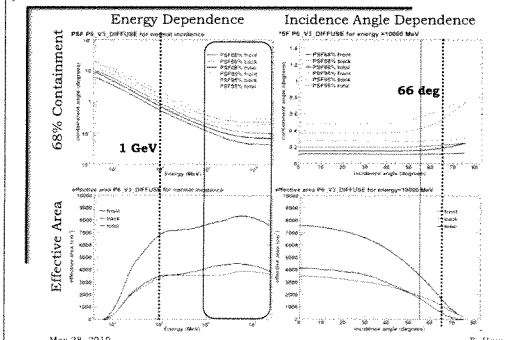
~390 Scientific Members including 90 Affiliated Scientists, plus 66 Postdocs and 100 Students

Managed at SLAC

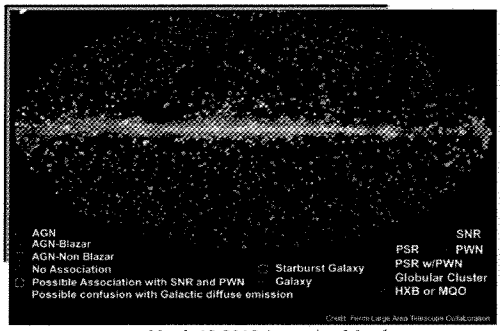
Galactic Results from LAT

- 1FGL Galactic populations
  - The seen, the unseen, and the unknown
- Selected Highlights
  - Pulsars
  - Pulsar Wind Nebulae
  - Supernova Remnants
  - Transients
- Future Prospects

A GeV, wide-field Instrument

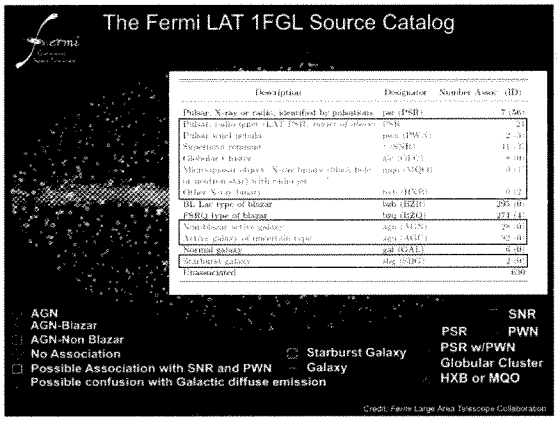


The 1FGL Catalog



May 28, 2010 *March 18 2010 Astro pic of the day* E. Hays

The Fermi LAT 1FGL Source Catalog



Unidentified Gamma-ray Sources

- Previous MeV-GeV energy gamma-ray missions left a legacy of "unidentified" sources (~2/3 of 3EG catalog)
  - Unidentified meant multiple possible candidates OR no plausible candidates (unassociated)
- LAT first catalog <50% unassociated
- LAT associations greatly aided by
  - Dramatically improved gamma-ray localization
  - Dedicated catalogs of potential gamma-ray counterparts
  - Multiwavelength searches
- LAT identifications from
  - Periodicity
  - Spatial morphology
  - Correlated variability with other observations

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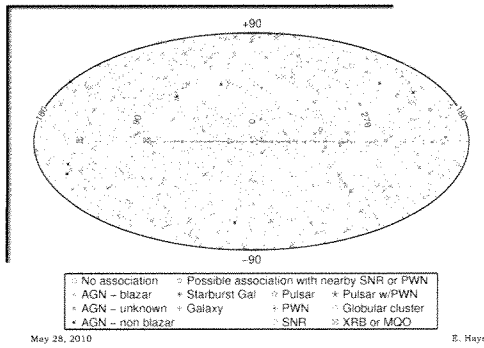
Variability in 1FGL Sources



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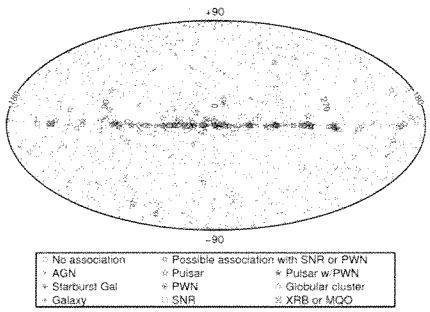
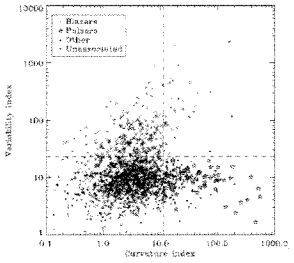
Curvature in 1FGL Sources



Spectral-Variability Classification

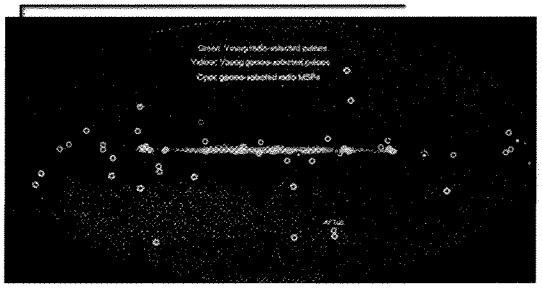
- Separability of blazars and pulsars in the variability-spectral curvature plane



Pulsars and their wind nebulae

- Bright Nebulae in the GeV band

Gamma-ray Pulsars and MSPs

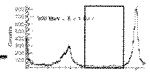


More than 56 gamma-ray pulsars in the first year
Plus gamma-selected MSPs
Abdo, A. A. et al. 2010, ApJS, 187, 460

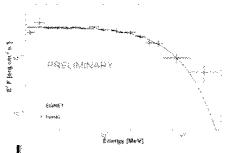
GeV PWN Search

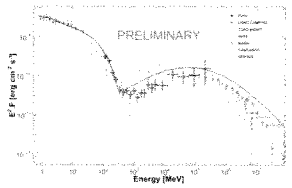
- Known high-energy PWNe
  - From X-ray and TeV observations
  - Crab, Vela X, MSH 15-52 nebulae...
- Off-peak searches of gamma-ray pulsars
  - Catalog from LAT team underway
- Young, energetic radio pulsars
- TeV nebula candidates

Crab Pulsar and Nebula



Pulsar 100 MeV to 20 GeV **Nebula** from MeV to TeV



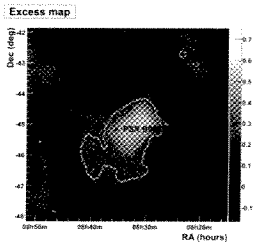


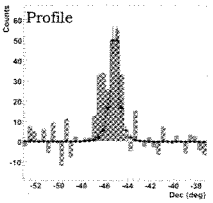
Hyper-exponential cutoff excluded at ~5 sigma. Consistent with emission well above the neutron star surface

Inverse Compton emission consistent with mean magnetic field in nebula 100 μG < B < 200 μG

 Abdo, A. A. et al. 2010, ApJ, 708, 1254

Vela X: Nebula of the Vela Pulsar



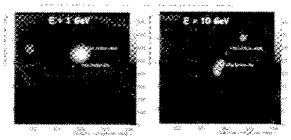


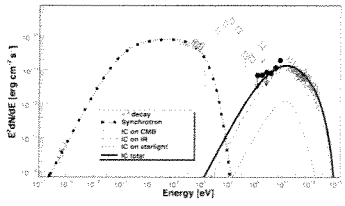
Excess counts E>800 MeV

Data compared with a simulated point source at position of Vela Pulsar

 Abdo, A. A. et al. 2010, ApJ, 713, 146

MSH 15-52





Supernova Remnants

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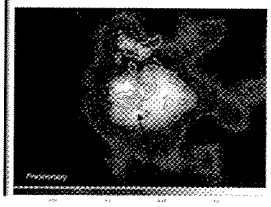
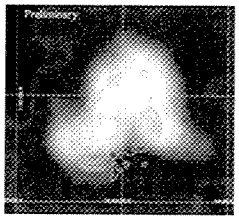
Resolved GeV Sources

Bright gamma-ray sources associated with several supernovae interacting with molecular clouds
Extension resolved in LAT data



LAT counts map (2-8 GeV)
X-ray (0.1-2.4 keV, black) and radio (1.4 GHz, green) contours



LAT counts map (2-10 GeV)
Radio (1.4 GHz, green) contours

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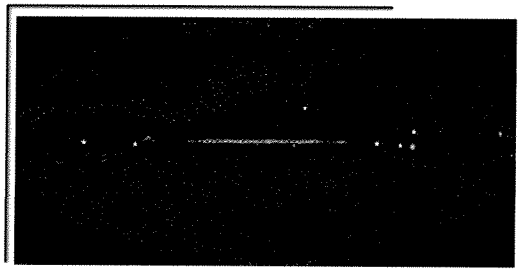
Galactic Transients

May 28, 2010 E. Hays

LAT Unassociated Transient Detections



☆ Unassociated transients from daily search
O Low latitude blazars from First LAT Catalog

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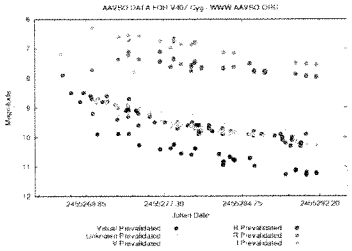
Gamma rays from a Nova

- Fermi J2102+4542
- Located in the direction of the Cygnus region
- Bright, high confidence, detected over several days by automated processing
- No likely blazars in error circle...

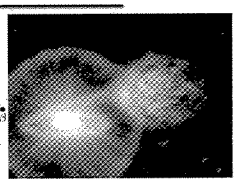
V 407 Cygni - a symbiotic nova

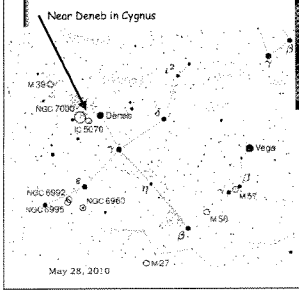
- Position and timing consistent with V 407 Cygni, a recurrent nova detected in outburst ~2 days before the Fermi report



V407 Cygni: a variable star

Symbiotic binary:
White dwarf star and red giant star orbiting each other





Variability from
- Mira variable star
- White dwarf accretion
- Binary interaction

A complex and fascinating system!

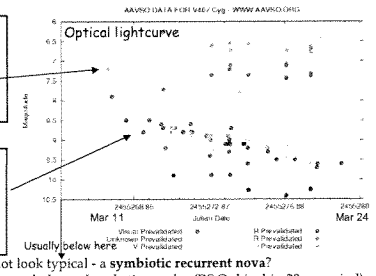
V407 Cyg ~ 6000 light years away

March 11 - A Nova!

Hydrogen accreting on to the surface of the white dwarf ignites a nuclear explosion (30-60 of these per year in Milky Way)

Candidate nova discovered by amateur astronomers, Nishiyama and Kobashima

Fermi detects a new gamma-ray source in the same field on March 13 (ATEL #2487)



Spectrum does not look typical - a **symbiotic recurrent nova**?
Very few systems explode on decade timescales (RS Ophiuchi ~20 yr period)

Symbiotic Nova

- Symbiotic Binary System: White dwarf + red giant system
- Nova: White dwarf builds up mass envelope to the point of thermonuclear fusion
  - Dramatic increase in visual magnitude
- Recurrent Nova?
  - Hints but no strong confirmation of previous nova
- Pre-nova activity
  - White dwarf shows ongoing variability at level of several in magnitude
  - V407 Cyg companion is a Mira star showing variability at level of several in magnitude
    - Dusty environment with stellar wind
- Origin of the gamma rays?
  - Strong shock propagating into dense medium around giant star (and stellar wind)
  - Pion decay or electron processes? (brehmstrahlung

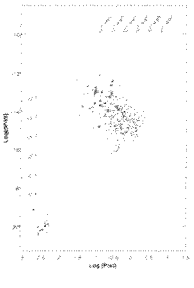
Summary

http://fermi.gsfc.nasa.gov

Extras

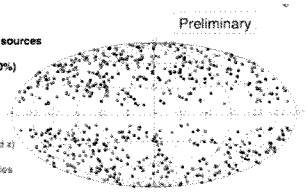
Pulsars everywhere...

- >50 gamma-ray pulsars so far
  - >40 young, energetic pulsars
  - 9 old, recycled millisecond pulsars
  - Identifying EGRET unidentifieds and LAT unidentifieds
- Gamma-ray beam is bigger than radio beam
- Pulsar spectra have exponential cutoffs in the GeV band
- Gamma rays from outer magnetosphere preferred
- Bonus: LAT unidentifieds also turning up new radio millisecond pulsars



Blazars

- 11 month data set
- 1079 TS>25, |b|>10° sources
- 668 AGNs (P_{assoc}>80%) +186 candidates
- Census:
  - 286 FSRQs
  - 284 BLLacs (141 with measured z)
  - ~10 Radio galaxies



Differences between Northern Hemisphere and Southern one (FSRQs: 7%, BLLACs: 25 %)

Posters: P5-188.S. Healey et al. P1-37.M. Shaw et al.